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HANDBOOK ON COMTAL'S IMAGE PROCESSING
SYSTEM

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INTRODUCTION

Modern technology utilizes all types of images as sources of information requiring interpretation and analysis. The growth in image processing technology has created the need for an automated system that could rapidly, accurately, and cost effectively extract useful information contained in images. This need is being met through systems such as the Comtal Vision One/20.

The concept of image processing stems from the utilization of computer techniques as a means of manipulating an image into a form which is more meaningful to the user. As a rule, image processing is the analysis and enhancement of two-dimensional data or the manipulating of imagery to present to the viewer, or a subsequent machine, additional information or insight into some factor concerning the original unprocessed image.

An image processing system is the combination of an image processor with other control and display devices plus the necessary software needed to produce an interactive capability to analyze and enhance image data. This handbook describes such an image processing system installed at NASA Langley Research Center, Instrument Research Division, Acoustics and Vibration Instrumentation Section (AVIS). Although much of the information contained herein can be found in the other references, it is hoped that this single handbook will give the user better access, in a concise form, to pertinent information and usage of the image processing system.

SYSTEM DESCRIPTION

The image processing system consists of a Comtal Vision One/20 Image Processor, a video camera, and a minicomputer with associated disc. Figure 1 shows the block diagram of the system.

Comtal Vision One/20 Overview

The Comtal Vision One/20 is a fully featured real-time interactive image processor that may be operated stand-alone or as a host computer peripheral. The processor features random access refresh memory.

The principle functions of the Comtal system are as follows:

1. To store images and graphic overlays in digital form
2. To acquire images from a vidicon camera, from built-in image generating functions, or from a system interface

3. To apply digital image processing algorithms to images. Some of the image processing functions are implemented in high speed pipeline processors such that they can be computed in one TV frame time. Parameters controlling the algorithms can be modified interactively by the operator and the results viewed in real-time.

4. To display the output image on a color monitor. It can also recapture it in digital memory or transmit it through a system interface to a host computer for further analysis.

5. To supply operator controls for interactive operation (keyboard, trackball, and a data tablet) and an extensive macro language for high level programming

Primary System Components

The major components of AVIS's Comtal system are:

1. Four 512 x 512 x 8 bit images with four 512 x 512 x 1 bit graphics refresh memories. This memory is dynamically reconfigurable to one 1024 x 1024 x 8 bit image with a single graphic plane.

2. One operator workstation equipped with:

a. Pipeline processors for parallel, real-time processing of one or more images

b. A very high spatial resolution (512 x 512) color monitor for viewing images and displaying character input commands and output data

c. A keyboard

d. A trackball and data tablet for interactive modification of process parameters

3. An LSI-11 system computer, which interprets the operator's commands, controls the Comtal and implements a large number of image manipulation functions

4. A monochrome vidicon camera with a color filter system so that images in color can be input to the system though not in real time.

5. An interface to a Hewlett Packard minicomputer which enables one to use the computer as the host for command data to the Comtal for transferring image data to or from the Comtal and for analysis of such image data.

The system block diagram of the Vision One/20 as installed in AVIS is shown in figure 2. The card and register operations are as follows:

1. REFM (Refresh Memory)

A. Stores digital data defining image/graphic components

1. Each card stores 1 megabit of data (512 x 512 x 4 bits).
(2 REFM cards are needed for each image (512 x 512 x 8 bits), or 1 REFM card can accommodate 4 graphic images (512 x 512 x 1 bit per image).

2. Utilizes 16K RAM chips

2. REFC (Image Refresh Data Base Control)

A. Controls video display operation and associated timing of refresh memories

1. Defines offset values for roaming

2. 1x, 2x, and 4x zoom control

3. Freeze frame write control

4. Raster mode control (standard - 559 line rate, 512 visible lines, 47 invisible; option - 525 line rate, 480 visible lines, 45 invisible)

B. Handles up to eight 512 x 512 x 8 bit images

C. Accessed through process bus (P-Bus)

3. RANC (Random Access I/O Control)

A. Controls data paths for input/output transfers (non-video) of the refresh memory

1. Accessed through LSI-11 addresses 170000-171300 octal

2. Two tables used for control

a. Virtual Memory Map - Translates virtual memory address to physical memory address

b. Channel Specification Table

1. Access to refresh memory via one of 16 channels

2. Registers define channels

3. Register addresses 1710000-171276

4. DMA through CSIO (see Comtal Standard Interface)

5. Handles up to eight 512 x 512 x 8 bit images

4. PLP (Pipeline Processor)

A. Contains the video data path selection and the processing of video data from refresh memory video output to the overlay card. Each card:

1. Handles four 512 x 512 images and four graphic planes
2. Two output ports
 - a. 29 bit (red, green, blue, graphic)
 - b. Expansion bus
3. Four function memory ports normally used for image data
4. Graphic control memory
 - a. Selection, coloring, and control decisions from 4 bit graphic bus
 - b. Controls image selection
- B. Used with convolver processing
- C. Accessed through P-Bus

5. OVLY (Overlay Control)

- A. Cursor/Target definition
- B. Pseudocolor Implementation
- C. Priority Selection
 1. Annotation
 2. Target/Dots
 3. Charts
 4. Grids
 5. Graphics
 6. Images
- D. Accessed on P-Bus

- E. One per user channel
- F. Freeze frame write selection
- 6. DACC (Digital-to-Analog Card)
 - A. Interface between OVLY and display monitors
 - 1. Produces appropriate video to drive a 559 line color RGB monitor
 - 2. OVLY card supplies composite sync to DACC
- 7. SYSC (System Computer)
 - A. 16 bit microprocessor LSI-11
 - 1. Byte or word addressable
 - 2. O/S executes on SYSC to control flow of data over Q-Bus
 - 3. Controls refresh of displays
 - 4. Interprets and executes user commands from keyboard
- 8. CSIO (Comtal Standard Interface)
 - A. Provides the link with host controller and Comtal
 - 1. LSI-11 or refresh memory transfers
 - 2. Four main registers
 - a. WC - Word Count, 2's complement
 - b. BAR - Buffer Address Register
 - i. Refresh memory transfers (defines I/O channel)
 - ii. LSI memory transfers (contains part of 18 bit address on Q-Bus which defines location to transfer)
 - c. CST - Command and Status Register
 - i. Controls transfer
 - d. RL - R Lines
 - i. Read only (contains contents of the 16 r-lines from the host control)

9. FRMW (Frame Write Multiplexor)

A. Data path selectors for loading refresh memories at video rates

1. Allows viewed imagery to be read back to memory
2. Controlled by REFC
3. Handles up to eight images
4. Accessed on P-Bus

10. ANDV (Ancillary Device Card)

A. Ancillary device connection between Comtal and input devices (trackball, data tablet, and keyboard)

B. Directly addressable on the Q-Bus

11. VID (FRGRB) (Video Input)

A. Provides means to digitize incoming analog video signal

B. Provides means to synchronize the device (i.e., a TV camera) producing analog video signal to Vision One/20 timing

1. 8 bit output
2. Input at PLP
3. No random I/O to video image

12. ICOM (Image Combine (option))

A. Real-time arithmetic operations: +, -, *, / of two images (pixel by pixel basis)

1. Selects two images determined by operator
2. Summation technique used with logarithmic and linear functions
3. Table loadable
4. Target position controls slope and/or offset
5. Tables can be displayed

13. CONV (Convolver (option))

A. Selects one of three 512 x 512 x 8 bit images from PLP expansion bus and performs 3 x 3 convolution

1. 3 x 3 kernel
2. 133 mega-operations per second
3. Laplacian, edge enhancement, gaussian

Operating System

The Comtal operating system is furnished in firmware (ROM) with additional RAM for user generated code. The firmware allows the Vision One/20 user to interact with the system controller (LSI-11) through a keyboard-orientated command language featuring a vocabulary of over 230 different commands. Thus, the command language allows the operator to work with all the resources of the system without having to learn how to program at the assembly language level. All of the commands consist of full-length English words, combined with numbers and a few symbols. However, it is not necessary to type the words in full. Each word has an abbreviation consisting of one or more of the first letters. When the space bar is pressed after typing the abbreviation, the system fills in the rest of the word. The system also checks the syntactical validity of each word as it is entered; if it is misspelled or entered at the wrong place in a command, the system displays a question mark and waits for the word to be re-entered correctly.

The command language is given in the Comtal Vision One/20 User's Manual (see reference 2). There are five different command families in the language.

1. MEMORY MANAGEMENT commands permit users to define their image size and depth (i.e., monochrome or color), scratch images and memory allocation.

2. PRESENTATION commands allow the system to combine images for display, adding graphics for labeling, outlining, and overlay.

3. PIPELINE PROCESSOR commands permit brightness corrections, analytical function loading, pseudocolor control, dynamic brightness correction adjustment, image roaming, zooming and arithmetic combination, and convolution implementation.

4. UTILITY commands permit keyboard programming, linking and chaining of instructions for macro construction and execution.

5. INPUT-OUTPUT commands allow image transfer to and from the Vision One/20 via the interface and the host computer.

The keyboard for entering the commands is shown in figure 3. In addition to the keyboard, the commands can also be passed into the system via the control interface which drives the system as if it were a special, high-priority user.

Comtal Display

On the color monitor, a few scan lines at the bottom of the screen are used, if desired, for lines of text which are used for typing input commands and displaying system responses and error messages. The rest of the screen contains an image display. What is actually seen in the displayed image may include any or all of the following components:

- A. A monochrome or sections of different monochrome images
- B. A truecolor image or sections of different truecolor images
- C. One or more graphics, overlaid on the image or images
- D. The effects of various kinds of image processing which are dynamically added to the displayed images
- E. A target which is a moveable, definable pointer controlled by the trackball and the data tablet
- F. Grid lines
- G. A graphical representation of one of the function memories

Images, graphics, function memories, and the target are discussed in the next sections.

IMAGES

An image is a digital representation of a picture. It has horizontal and vertical dimensions which are expressed in PIXELS. An image just large enough to fill the monitor screen is 512 pixels square. A pixel is the smallest independent unit of a picture and can be represented from 1 up to 24 bits of digital information. This range depends on the kind of image; 1 bit for graphic overlay, 8 bits for a monochrome image, or 24 bits for a full color image.

Monochrome Images

A monochrome image is a picture in which each pixel is coded as 8 bits of information. Thus, the picture can display gray levels similar to those appearing in an ordinary black and white photograph. Each pixel can be black (pixel value = 0), white (pixel value = 255), or any value in between.

A major part of the processing power in the Comtal system is devoted to processing pixels. By processing monochrome images, a pseudocolor image can be displayed. A pseudocolor image is a color image obtained by arbitrarily adding colors to a monochrome image usually with the objective of highlighting features not readily visible in monochrome.

Truecolor Images

A truecolor image is a picture in which each pixel is coded as 24 bits. These are divided into three groups of 8 bits which independently contain "gray levels" of the red, green and blue components of the pixel. In effect, a truecolor image can be regarded as a stack of three monochrome images--one colored red, one green, and one blue. This is exactly how the image is constructed by the Comtal. A truecolor image is made up of three previously defined monochrome images. When it is displayed, each monochrome image is applied to one of the three color guns in the monitor.

Processing Images

The system can process images in several different ways.

1. Pixel Modification

The gray level in each individual pixel is modified, depending on:

- a. the original level of the pixel
- b. the original level and the gray levels in the corresponding pixels of one or more similar images
- c. the original level and the gray levels in adjacent pixels of the same image

Usually pixel modification algorithms are implemented in pipeline processors and can be executed in 1/30th of a second.

2. Pixel Translation

The output image may contain pixels selected from specific areas of a stored image, translated and/or magnified in the pipeline processors.

3. Image Composition

An image can be modified by copying parts of other images into it. The state of each individual pixel can be controlled by:

- a. specifying a particular rectangular area of an image to be copied
- b. copying only those pixels for which a corresponding bit is set in a graphic overlay
- c. setting a specific area, selected by either (a.) or (b.) to gray levels determined by a mathematical algorithm

4. Image Creation by the User

By drawing, typing characters, or by entering macro language commands, the user can create diagrams and test patterns directly at his workstation.

GRAPHICS

A graphic is a picture in which each pixel is represented by only one bit. Each pixel has only two possible states--either white (bit value = 0) or black (bit value = 1). However, the system stores a color attribute for the graphic as a whole which can be set to any of sixteen different colors (see table 1). When a color is selected, the entire graphic will appear on the screen as a set of lines and shapes all of the same color.

Graphics can be used for storing masks. Masks are used to delineate areas on other images which are to be selectively processed in some way. Graphics can also be used as follows:

1. to contain line drawings, characters, and grid lines
2. to store graphs showing density profiles along any horizontal or vertical line through an image

FUNCTION MEMORIES

A "function memory" is a look-up table of gray levels that designates output pixel intensity values corresponding to input intensity values. When the look-up table is activated, some or all of the pixels in the displayed image are modified. For example, if the 200th location in the table has a value of 85, then any pixel with a gray level of 199 will be changed to gray level of 85. The original value remains in image memory. The substitution of 85 for 199 is done in the pipeline processors. When the use of the look-up table is discontinued, the original gray level returns to the display.

Typically, the function memories are used to change contrast in a monochrome image, to modify the colors of a truecolor image or to apply artificial coloring so as to highlight hidden details. Also integer and real functions can be used to "design" a function memory to achieve special effects. The AVIS system contains three kinds of function memories: principal function memories, pseudocolor memories, and function tables.

Principal Function Memories

Whenever memory is allocated for an image, a corresponding hardware register is reserved for a function memory. The function memory is uniquely associated with that particular image and is identified by a number equal to the image number. When an image is being used as the principal image on the monitor screen, its gray levels can be modified by invoking its function

memory. It can only be modified by its own function memory. If the image is not being displayed, its function memory cannot alter the displayed image.

Pseudocolor Memories

At the workstation there are three pseudocolor memories identified as red, green and blue. They are not associated with any particular image. They can be applied to the displayed image regardless of which image numbers are being displayed. The pseudocolor memories can be activated either singularly or in combination.

Function Tables

The system provides for up to eight function tables. These are simply places where sets of values for the other kinds of function memories can temporarily be stored. The function tables take no direct part in processing. They serve merely as holding areas for extra look-up tables.

TARGET

The target, operating independently of either the image or the graphic presentation, consists of a unique pattern of pixels such that it is visible in any combination of image and graphic data which is being displayed. The default value of the target is a 3 x 3 pixel matrix with a centered cross. The upper left hand corner of the target defines its x,y location.

The target is also programmable. Maximum dimensions of the target are 16 pixels in x (horizontal) direction and 16 pixels in y (vertical) direction. Each line of new target is entered as a six digit octal number representing a bit pattern for the on (1) and off (0) bits. The target can be set to any of eight different colors (see table 1).

OPERATING TECHNIQUES

This section describes a few techniques that can be used to obtain various desired results when using the Comtal Vision One/20 system. More techniques are described in subsequent sections.

System Turn-on

After the power is turned on, the space bar should be depressed to initialize the system. The system comes up with images 1, 2, 3 and 4 and graphics 1, 2, 3 and 4 set. The operating prompt "*" appears in the lower left hand corner of the display, and image 1 appears on the main display area.

In addition, when the system is initialized, image 8 is already defined as a truecolor image. However, to actually attain the color representation in image 8, the red, green and blue components must be assigned to selected images.

Example: ASSIGN TRUECOLOR 8 RED 1 BLUE 2 GREEN 3

This command specifies that image 1 will be the red component, image 2 the blue component and image 3 the green component. Images 1, 2 and 3 will normally be the color components but do not have to be so.

In order to use the target, the ADD TARGET command must be issued since it does not appear when the system is turned on. The target can then be set to any desired x,y location by using commands such as TRACE GRAPHIC or DUMP IMAGE.

In the initial state, only one line of annotation appears at the bottom of the screen.

System Reset

To reset the system type "~" and any key. This removes the target; releases any memory allocated by set commands for macros, codes, etc.; destroys dimension and parameters set after the initial state; and removes all color attributes. Images 1, 2, 3 and 4 remain as they were before the reset. All other images are lost. Graphics 1, 2, 3, 4 remain as they were before reset except that there is no color attribute to them.

A Better Target

As stated previously, the default target is a 3 x 3 cross. The following sequence defines a target with which it is easier to find the x,y location on the desired image.

DEFINE TARGET X6 Y6 - This command defines the target size as 6 x 6.
Enter the following line values:

Line 001 176000

Line 002 176000

Line 003 140000

Line 004 140000

Line 005 140000

Line 006 140000

Use the command ADD TRANSPARENCY OF TARGET to display only those bits which are not zero.

USING FUNCTION SWITCHES

Keys A through O

The default functions of the Alpha-Pad keys (figure 3) are given in table 2. However, function keys A to O can also be used to enter the commands EXECUTE MACRO A, EXECUTE MACRO B, etc. To obtain this result, the key to the left of the RETURN key (\) should be pressed followed by the appropriate key representing the desired macro.

It is possible to use the keys to invoke any of the commands listed in table 2 while concurrently executing a command entered from the keyboard. For example, one may issue - ROLL FUNCTION MEMORY 1. Image 1, function memory 1, and image 1 plus function memory 1 can be alternately displayed while simultaneously controlling the rolling function with the trackball.

Keys FS1 through FS5

Function switches 1-5 are used to invoke special effects associated with some commands that allow the user to manipulate the image. Following is the capability of each key:

FS1 is the function switch labeled "1" on the left edge of the Comtal keyboard. The switch, when set, activates the target so that the current target position is relayed to the current interactive command. The interactivity is disabled when the switch is reset (depressed again). A trackball used as an interactive device will be enabled when FS1 is set after a command is typed (i.e., ROAM IMAGE, then FS1, then roll the trackball in the desired direction). Users with data tablets can depress the stylus to achieve the same effect as FS1. On some commands FS1 is reset immediately after it is set and one coordinate pair is sent to the command (i.e., on FILL GRAPHIC n, the switch is reset immediately and must be set for each new area to be filled).

FS2 is the function switch labeled "2" on the left edge of the Comtal keyboard. This switch serves a number of purposes depending on the command being executed. Two of the more prevalent functions are: (a) when set, TRACE writes black (0's or erase for graphics, 0 for image); when reset, TRACE function writes white (1's for graphics, 225 for image); (b) for PROFILE, when set, profile of targeted X line is done; when reset, profile of X line is not done.

FS3 is the function switch used for two primary purposes: (a) when executing some interactive commands, the ROAM command can be momentarily entered by setting FS3. The image can then be roamed to the desired location, the ROAM mode exited by using one (ESC) and the normal command resumed;

(b) when creating a PROFILE, a profile of the Y line is done when FS3 is set, and is not done if FS3 is reset.

FS4 is a function switch used for two primary purposes: (a) when tracing into a function memory, graphic, or image, FS4 is set when interpolation between endpoints is desired, the interpolating being done by the LSI-11 processor; and FS4 is reset if no interpolation is desired; (b) FS4 is set to indicate upper left corner on SET CORNERS and reset to indicate lower right corner.

FS5 is the function switch used to "reset to original state". In tracing function or pseudocolor memories, FS5 will restore the memory to its original contents before the trace, if FS5 is set before the trace command is terminated. In ROAM, FS5 resets the image so that coordinate (0,0) is at the upper left corner of the display. In convolving, FS5 resets the target to screen center and convolution matrix coefficients to their initial values.

ADD/DISPLAY PRIORITIES

When several components have been included in the displayed image by issuing DISPLAY and ADD commands, each component has a priority attribute which determines whether or not it will be displayed if some other component occupies the same pixel.

In increasing priority, the order is as follows:

1. Principal Image - This is the lowest priority; a pixel of the principal image can be overwritten by any other component.

2. Gray Scale - This replaces the principal image when ADD GRAY SCALE command is issued.

3. Graphic - Graphic pixels containing 1 bits replace image pixels. However, if the ADD TRANSPARENCY OF GRAPHIC command has been issued, each pixel of the displayed image contains an average of the highest priority graphic pixel and the image pixel at the point. Graphic pixels containing 0 bits are invisible. They form a white background if a graphics priority is displayed by itself, but otherwise among the graphics, priority is established depending on the order of adding them. The last graphic added has the highest priority.

4. Bars - Pixels which fall under a bar are replaced by the bar, regardless of bar color.

5. Black Screen - When the black screen is displayed, all of the above components are removed from the screen except the target and annotation characters.

6. Target - The target replaces both the image and graphic pixels. Target pixels which have been set to 1 are displayed in the target color, while those set to 0 are black.

7. Annotation Characters - These have the highest priority. They replace what was displayed in the bottom 24 scan lines of the displayed image.

MACROS

MACROS are groups of commands which are executed as individual entities. They can be coded directly into the LSI-11 memory from the keyboard or they can be prepared at the host and transmitted to the Comtal system via the interface. In the Vision One/20, the capability exists to create up to 15 macro commands, each assigned to one of the 15 key Alpha-Pad letters A-O (figure 3). The macros are stored as ASCII strings in the LSI memory and each macro can have no more than 128 ASCII characters.

To use the macro capability, the necessary LSI memory must be allocated. This is done by the command SET MACRO. Once the necessary memory is allocated, a sequence of commands for each macro can be created. The command CREATE MACRO Z, where Z is any of the letters A-O, will cause entry into the MACRO edit mode. The edit mode not only allows for the creation of a macro, but also allows one to modify an existing macro. In the edit mode, if the macro already exists, the first line of code is displayed followed by the character (/). If there is no prior definition, only the (/) is displayed. The macro edit commands that can be used are:

Insert. - Puts the system into Macro Text mode, allowing for the addition or insertion of code after the currently displayed macro line. Comtal displays the character to indicate the MACRO TEXT mode. After entering a line of the macro, type a space and Linefeed to proceed to the next line. To return to the MACRO edit mode use the Carriage Return key.

Back. - Displays previous macro line.

Next. - Displays next line.

Delete. - Deletes displayed line.

Exit. - Terminates MACRO editor.

The macro can be executed by typing the EXECUTE MACRO Z command where Z is the macro name (A-O) or by typing the backslash next to the RETURN key (figure 3) followed by the appropriate letter function key.

Notes:

1. Defining a macro has no effect on the assignments of the function keys.

2. Commands which require use of the function switch (such as GRAPHIC=LABEL) cannot be executed from a macro. The GRAPHIC=LABEL command can

be coded in the macro, but the program then stops at the point where the function switch 1 would be pressed.

3. To execute a macro repeatedly, use the command BRANCH MACRO which is similar to an unconditional GO TO in Fortran. A macro can also call itself by using the EXECUTE MACRO Z command at the end of the macro. However, the limit of one macro calling itself is eight items. To execute another macro within a macro, use the EXECUTE MACRO command which will execute a macro and return to the next command in the master macro.

VIDEO INPUT

To use the camera to input an image to the Comtal, the following commands must be entered:

SET VIDEO IMAGE m - This command assigns image m (any unassigned image number) as the label for the video input. A system restriction is to never use this video image as a destination for random I/O. Any random I/O attempt will cause the system to automatically time out and restart.

DISPLAY IMAGE m - This displays on the monitor the image that is on the camera and allows the user the opportunity to align and focus the image.

IMAGE n = DISPLAYED IMAGE RGB - (Where RGB is the Red, Green, or Blue component.) This copies the video image to an assigned image n (1, 2, 3, or 4) so that random I/O can be done. If the image is monochrome, the color component has no effect but it must be used in the command. If the image is color, the appropriate filter on the color wheel should be over the image prior to issuing the command. This command should be issued three times with the Red, Green and Blue components assigned to three different images.

DISPLAY IMAGE n - This command assures that the desired video image has indeed been assigned. If the image is truecolor, use the commands:

ASSIGN TRUECOLOR 8, RED k, GREEN l, BLUE m - This command assembles the three color components of the truecolor image where k, l, and m are the appropriate images.

DISPLAY IMAGE 8 (or press function switch M) - This command displays the truecolor image.

ENHANCING IMAGES

In order to enhance an image, function memory processing should be applied to the displayed image. Use the commands:

ADD FUNCTION MEMORY n, (RGB) - This will result in changes in the density levels of the displayed image n. If the displayed image is in monochrome, the function memory applies a monochrome image transformation. If the displayed image is in truecolor and, if no color parameter is supplied, the three color

channels are separately processed by the function memories corresponding to the assigned red, green and blue images. If the color parameter is entered, only the specified component of the image is affected. The density level changes in a true color image results in changes of color.

FUNCTION MEMORY n, (RGB) = HISTOGRAM OF IMAGE - This command obtains a histogram of the density levels in a monochrome or truecolor image. The LSI-11 counts all the occurrences of each gray level from 0 to 255 in the specified image. The counts are then multiplied by 256, divided by the highest count, and transferred into the function memory. If image n is truecolor, independent histograms are obtained for all three color components unless a color parameter is specified in the command.

Note: The computation time for the histogram of a 512 x 512 image is about 45 seconds; for larger or truecolor images, it is proportionately greater.

EQUALIZE FUNCTION MEMORY n (RGB) - This command obtains a normalized integral of the data in the function memory. If function memory n is of a truecolor image, and if RGB is not specified, all three components of the function memory will be equalized independently of each other.

Note: Equalizing a function memory will always result in an image contrast value of one. This is because the lowest intensity value of the normalized integral in the equalized function memory is always zero, regardless of the lowest intensity value of any pixel in the original image.

If desired, use the command:

ROLL FUNCTION MEMORY n - This command causes the function memory to move from left to right or from right to left under control of either the data tablet or the trackball. The user can view the image or the function memory noting the contrast of the image.

ERROR MESSAGES

The system issues only a few cryptic error messages. There are no error codes or other explanatory information. The exact reason for the error is often dependent on the specific command being executed. The messages one may see and the general errors which may cause them are as follows:

● ?

The question mark appears whenever the last word of the command currently being entered is invalid. The system ignores the invalid word, (although any valid words entered before it are retained.)

To recover, enter a correctly spelled word, followed by whatever other words may be required to complete the command, or press the ESCAPE key to cancel the entire entry.

● *****NOT DEFINED*****

The command just entered contains a reference to an image or graphic which has not yet been defined. To recover, enter a command to establish a definition (such as SET IMAGE) then retry the command which has failed.

● *****ALREADY DEFINED*****

A definition for an image or graphic number has been entered which is already in use. To recover, omit the definition or re-enter it with another number not yet used.

● *****NOT ASSIGNED*****

The command just entered invokes a device which is not assigned to your workstation (usually a tape drive). To recover, issue the appropriate ASSIGN command then retry the command which failed.

● *****ABORTED*****

A command has been issued which, for some reason, cannot be executed. Consult the page dealing with the command to find out what has been done wrong.

● *****RESOURCE BUSY*****

The command just entered cannot be executed because some system resource which it requires is not available. In some cases, the resource may become available in time after a background task has been completed. In other cases, specific action may have to be taken to free it.

Resources which may incur contention in this way include:

physical image memory
LSI-11 memory
image memory ports
some software modules

To recover, it is usually necessary to abort the command by pressing ESCAPE (ESC). Then issue commands (such as RELEASE IMAGE) to release the resource in contention.

● *****OVERFLOW*****

This message occurs only during macro definition. It indicates a macro has been defined which is too large to fit in the available space (128 bytes). To recover, delete some lines from the macro and close the definition with the EXIT command.

SPECIAL NOTES

1. In order to see what is behind a graphic, use the ADD TRANSPARENCY OF GRAPHIC command. There is no need to specify a graphic number with this command since it applies to all graphics.

2. In order to do window processing or image profiles, a graphic must be added to view results.

3. Always depress the space bar between x and y and constants when setting arithmetic functions.

4. Color tones can be added to black and white pictures by using the color wheel during input and assigning appropriate colors.

5. The SET FLAG command must be issued in order to recognize dimensions created by the SET CORNERS or DEFINE CORNERS commands (window processing). This allows for certain processing operations on image or graphics pixels inside the window. For an image, the following commands will be effected only inside the window:

```
CLEAR IMAGE
FUNCTION MEMORY = HISTOGRAM OF IMAGE
GRAPHIC = IMAGE LEVEL
IMAGE = CONSTANT
IMAGE = IMAGE
```

For a graphic, the following commands are affected:

```
CLEAR GRAPHIC
FILL GRAPHIC
GRAPHIC = GRAPHIC
GRAPHIC = IMAGE LEVEL
```

The CLEAR FLAG command revokes the SET FLAG command. All of the operations listed will then process the entire image or graphic.

6. The following commands must be issued to claim memory space for arithmetic functions codes, macros, and tables:

```
SET INTEGER FUNCTION
SET REAL FUNCTION
SET CODE
SET MACRO
SET TABLE
```

RELEASE commands are for revoking these commands.

OPERATING WITH HP COMPUTER

With the Hewlett Packard (HP 1000) computer an orderly sequence of events for the entire processing system can be organized and controlled. One of the principal functions of the computer is to locate and control the transfer of data from the original source to the refresh memory in the image processor. It can also generate the required pixel patterns for the graphics overlays and control their display in conjunction with their images. The contents of the memories of the function processors and pseudocolor processor can be controlled by the computer. The contents of these memories can be fed back to the computer for further analysis. The X-Y position data can also be accessed through the standard I/O interface.

Starting the System

In order to use the HP computer the RTE (Real-Time Executive) operating system must be loaded into memory (booted-up). The following steps must be implemented to manually boot up the system. (See figure 4 of the front panel of the computer.)

1. Press HALT
2. Turn on all switches
3. Select the S-Register
4. Enter the following bit pattern into the display register
0100001010000000
5. Press STORE to load the display register into the S-Register
6. Press PRESET
7. Press IBL
8. Press PRESET (again)
9. Press RUN

After information is presented on the system terminal, operator commands can be entered. If not at the system terminal, strike a key on the available terminal. The system will print:

PLEASE LOG-ON:

The operator should enter:

NET.SESS space bar

If at the system terminal, type:

EX space bar
strike a key and enter
EN space bar

Strike another key and the system will ask the operator to log on. After logging on as in the above manner, all Comtal files and programs can be accessed.

Image Transfer between Computer and Comtal

In order to transfer image data between the computer and the image processor a disc file used for storage of image data must reside on a cartridge. If a file does not exist, one must be created. To create a disc file the following command must be entered.

```
CR:CFNAME::CR#:2:file size:256
```

where

CFNAME - name of the file assigned by the user
CR# - cartidge number where the file will reside
2 - file type
file size - 1024 for B/W image, 3072 for color image
256 - Record size

(Example: CR:CFGET::26:2:3072:256)

This creates on cartridge 26 a file name CFGET where color images can be stored. Most of AVIS's image files used for demonstration purposes are located on cartridge 26. These files are:

CFSANF - Color image of San Francisco
CFMAND - Color image of a Mandril
CFLAND - Color images of Landsat
CFBRIG - Black and white image of a Bridge
CFXRAY - Black and white image of an x-ray of the human body

Program IMSRW located on cartridge 17 writes specified images to or from the Comtal. A print out of this program is given in Appendix B, "COMTAL PROGRAMS (for use in the HP 1000 computer)".

CONCLUDING REMARKS

The Comtal image processing system is a complete image processing system providing built-in interactive processing and control capabilities as well as allowing for operation with a host computer.

Despite its versatility, however, there have been some obstacles encountered with the system. Problems occurred in several of the wire-wrapped integrated circuit boards in both the circuitry and the electrical connector contacts. Moreover, the Comtal only allows for a camera as a video input. Interfacing other video devices such as a recorder or disc has proven to be a difficult task. It is hoped that this difficulty can be overcome in the near future in view of the new developments that are now occurring in this area.

APPENDIX A

(Examples)

Using Graphics for Labeling

To place alphanumeric labels into a graphic, first position the target to the desired location since the upper left corner of the first character is placed at the location specified by the target position. Use the commands:

```
ADD TARGET
DUMP IMAGE
```

With this command the target can be moved to the desired location by using the trackball or the data tablet. Use the ESC key after the target is located.

Alternatively, the target can be placed at a specific location using the command:

```
SET TARGET COORDINATES Xkkk Ymmm, where kkk and mmm are the desired
x,y locations.
```

Use the following commands to label:

```
CLEAR GRAPHIC n, where n is the graphic to be used for labeling.
ADD GRAPHIC n
GRAPHIC n = LABEL BY FACTOR m, where the size of the characters is
a function of m.
```

Depress FS1 key and begin inputting the label from the keyboard. A LINEFEED at the end of the input line allows more lines to be entered. A RETURN terminates the input.

Labels can be colored by using the command: COLOR GRAPHIC n cname, where cname is the color. If graphic n is already on the display, ADD or DISPLAY again to see color change.

Window Processing

The following example takes the left side of image 1 and the right side of image 2 and transfers them to image 3 (Split Screen Effect).

```

DISPLAY IMAGE 1
DEFINE CORNERS IMAGE 1 X1 0 X2 255 Y1 0 Y2 511 - left side of
image 1
DEFINE CORNERS IMAGE 3 X1 0 X2 255 Y1 0 Y2 511 - left side of
destination image 3.

```

If corners are not defined the image will be centered in the destination image.

```

SET FLAG IMAGE 2
SET FLAG IMAGE 3
IMAGE 3 = IMAGE 1
CLEAR FLAG IMAGE 1
CLEAR FLAG IMAGE 3
DISPLAY IMAGE 2
DEFINE CORNERS IMAGE 2 X1 256 X2 511 Y1 0 Y2 511 - right side of
image 2
DEFINE CORNERS IMAGE 3 X1 256 X2 511 Y1 0 Y2 511 - right side of
image 3
SET FLAG IMAGE 2
SET FLAG IMAGE 3
IMAGE 3 = IMAGE 2
CLEAR FLAG IMAGE 2
CLEAR FLAG IMAGE 3
DISPLAY IMAGE 3

```

Pseudo Image

A pseudo image, which does not require refresh memory, is created through the use of DEFINE and ASSIGN commands, and may be either TRUECOLOR, or made up of four real or pseudo images. If non-truecolor, the pseudo image must be square, larger than 512 x 512, and the images used for the four quadrants must be of equal size, whether real images or other pseudo images. If truecolor, the pseudo image may be composed of three real images of any size. The following commands sets a 1K by 1K pseudo image composed of images 1, 2, 3, and 4.

```

DEFINE IMAGE 9 X1024 Y1024
ASSIGN IMAGE 9 W1 1 W2 2 W3 3 W4 4
DISPLAY IMAGE 9

```

The upper right hand quadrant will be displayed. To see the other parts, use the ROAM command.

Smoothing Images

To smooth an image that is displayed, position the target to the desired location. The position of the target specifies the pixel whose value is to be replaced by the average value of the eight pixels surrounding it. Use the command:

SMOOTH IMAGE

Depress FS1 key to enable smoothing by the trackball. Move the target until desired effect is achieved.

User-Specified Arithmetic Statement Functions (USAF)

A USAF can be either a integer function or a real function defined by the user. In order to use a USAF, LSI-11 memory must be allocated.

To create, with a real function, a two-dimensional gray scale in image 1, use the command:

```
CLEAR IMAGE 1
SET REAL FUNCTION 1
REAL FUNCTION 1 = REAL (X*Y/Constant 1024)
IMAGE 1 = REAL (REAL FUNCTION 1)
```

The value ranges for $X*Y$, assuming image 1 is 512 x 512, are 0-511. The maximum pixel value for an 8-bit monochrome image is 255. So $X*Y/1024$ will provide pixel values from 0-255, ranging from the upper left corner (0,0) as black, to the lower right corner (511,511) as white. To see the image with pseudo-color added, depress the D key on the Alpha-Pad. To stop the function at any point, reset the system.

APPENDIX B

(Comtal Programs: for use in HP 1000 Computer)

&IMSRW T=00004 IS ON CR00015 USING 00004 BLKS R=0000

```

0001 FTN7X.L
0002 C
0003 C
0004 C *****
0005 C * THIS PROGRAM DOES THE FOLLOWING: *
0006 C * *
0007 C * A. READS "SPECIFIED" IMAGES FROM THE COMTAL AND STORES ON A DISC *
0008 C * FILE OR *
0009 C * B. WRITES "SPECIFIED" IMAGES TO COMTAL FROM DATA STORED ON A DISC *
0010 C * FILE *
0011 C *****
0012 C
0013 C
0014 C
0015 PROGRAM IMSRW
0016 DIMENSION IBUF(256),IDCB(144),INAM(3)
0017 5 WRITE(1,10)
0018 10 FORMAT("ENTER IMAGE NAME")
0019 READ(1,25) INAM
0020 25 FORMAT(3A2)
0021 CALL OPEN(IDCB,IERR,INAM)
0022 IF(IERR.LT.0)GO TO 999
0023 30 WRITE(1,35)
0024 35 FORMAT("ENTER IMAGE NO.")
0025 READ(1,*)INUM
0026 IF(INUM.LT.0)GO TO 999
0027 WRITE(1,40)
0028 40 FORMAT("ENTER 1=READ IMAGE FROM COMTAL, 2=WRITE IMAGE TO COMTAL")
0029 READ(1,*)INS
0030 39 DO 100 LINE=1,512
0031 ICMND= ((INUM-1)*2048+(LINE-1))
0032 IF(INS.EQ.2) GO TO 50
0033 CALL EXEC(1,136B,IBUF,256,ICMND)
0034 CALL WRITE(IDCB,IERR,IBUF)
0035 GO TO 100
0036 50 CALL READF(IDCB,IERR,IBUF)
0037 CALL EXEC(2,136B,IBUF,256,ICMND)
0038 100 CONTINUE
0039 GO TO 30
0040 999 CALL CLOSE(IDCB,IERR)
0041 END

```

&IMGDC T=00004 IS ON CR00017 USING 00003 BLKS R=0000

```

0001  FTN7X,L
0002  C
0003  C
0004  C      ****
0005  C      *
0006  C      *  THIS PROGRAM TRANSFERS IMAGE DATA FROM DISC TO COMTAL  *
0007  C      *
0008  C      *  ; USES DVR41
0009  C      *
0010  C      ****
0011  C
0012  C
0013      PROGRAM IMGDC
0014      DIMENSION IBUF(256),INAM(3),IDCB(144)
0015      LU=30
0016  5    WRITE(1,10)
0017  10   FORMAT("ENTER IMAGE FILE NAME")
0018      READ(1,20)INAM
0019      WRITE(1,11)
0020  11   FORMAT("ENTER 1=B/W, 3=COLOR")
0021      READ(1,*)ICL
0022  20   FORMAT(3A2)
0023      CALL OPEN(IDCB,IERR,INAM,3)
0024      IF(IERR.LT.0)GO TO 800
0025      DO 100 J=1,ICL
0026      DO 100 LINE=1,512
0027      ICMND=((J-1)*2048+LINE-1)
0028      CALL READF(IDCB,IERR,IBUF)
0029      IF(IERR.LT.0)GO TO 850
0030      CALL EXEC(2,1008+LU,IBUF,256,ICMND)
0031  100   CONTINUE
0032      GO TO 999
0033  800   WRITE(1,810)IERR
0034  810   FORMAT("OPEN ERR=",14)
0035      GO TO 999
0036  850   WRITE(1,860)IERR
0037  860   FORMAT("WRITE ERR=",14)
0038  999   END

```

&IMGWT T=00004 IS ON CR00017 USING 00002 BLKS R=0000

```
0001 FTN7X.L
0002 C
0003 C
0004 C      ****
0005 C      *
0006 C      * THIS PROGRAM TRANSFERS IMAGE DATA FROM *
0007 C      * M.T. TO COMTAL ;  USES DVR41              *
0008 C      *
0009 C      ****
0010 C
0011 C
0012      PROGRAM IMGWT
0013      DIMENSION IBUF(256)
0014 5      WRITE(1,10)
0015 10     FORMAT("ENTER IMAGE NO.")
0016      READ(1,*) INUM
0017      IF(INUM.LT.0)GO TO 999
0018      DO 100 LINE=1,512
0019      CALL EXEC(1,1100,IBUF,256)
0020      ICMND= ((INUM-1)*2048+(LINE-1))
0021 100    CALL EXEC(2,1360,IBUF,256,ICMND)
0022      GO TO 5
0023 999    END
```

&IMGTD T=00004 IS ON CR00017 USING 00003 BLKS R=0000

```
0001  FTN7X.L
0002  C
0003  C
0004  C
0005  C      ****
0006  C      *
0007  C      *  THIS PROGRAM TRANSFERS IMAGE DATA  *
0008  C ;    *  FROM M.T. TO DISC ; USES DVR41      *
0009  C      *
0010  C      ****
0011  C
0012  C
0013      PROGRAM IMGTD
0014      DIMENSION IBUF(256),INAM(3),IDCB(144)
0015  5      WRITE(1,10)
0016  10     FORMAT("ENTER IMAGE FILE NAME")
0017      READ(1,20)INAM
0018  20     FORMAT(3A2)
0019      WRITE(1,30)
0020  30     FORMAT("ENTER 1=B/W, 3=COLOR")
0021      READ(1,*)ICL
0022      CALL OPEN(IDCB,IERR,INAM,3)
0023      IF(IERR.LT.0)GO TO 800
0024      DO 100 J=1,ICL
0025      DO 100 LINE=1,512
0026      CALL EXEC(1,1100,IBUF,256)
0027      CALL WRITF(IDCB,IERR,IBUF)
0028      IF(IERR.LT.0)GO TO 850
0029  100    CONTINUE
0030  800    WRITE(1,810)IERR
0031  810    FORMAT("OPEN ERR=",I4)
0032      GO TO 999
0033  850    WRITE(1,860)IERR
0034  860    FORMAT("WRITE ERR=",I4)
0035  999    END
```

&JRIMG T=00004 IS ON CR00017 USING 00002 BLKS R=0000

```
0001  FTN7X.L
0002  C
0003  C
0004  C      ****
0005  C      *
0006  C      *  THIS PROGRAM READS THE IMAGE ONE LINE *
0007  C      *
0008  C      *  AT A TIME ; USES %RDIMG AND %COMIM      *
0009  C      *
0010  C      ****
0011  C
0012  C
0013      PROGRAM JRIMG
0014      DIMENSION IBUF(50)
0015      LU=30
0016      IMNUM=1
0017      LINE =0
0018      LEN=50
0019      CALL RDIMG(LU,IMNUM,LINE,IBUF,LEN,IERR)
0020      WRITE(1,20)IBUF(1),IBUF(50)
0021  20    FORMAT(3X,06,3X,06)
0022      WRITE(1,200)IERR
0023  200   FORMAT("IERR=",I4)
0024      END
```

&IMGRW T=00004 IS ON CR00015 USING 00003 BLKS R=0000

```
0001  FTN7X.L
0002  C
0003  C
0004  C      ****
0005  C      *
0006  C      *    THIS PROGRAM READS OR WRITES ONE LINE OF IMAGE    *
0007  C      *
0008  C      *    ; USES DVR41
0009  C      *
0010  C      ****
0011  C
0012      PROGRAM IMGRW
0013      DIMENSION IBUF(256),IDCB(144),INAM(3)
0014  5      WRITE(1,10)
0015  10     FORMAT("ENTER IMAGE NAME")
0016      READ(1,25) INAM
0017  25     FORMAT(3A2)
0018      CALL OPEN(IDCB,IERR,INAM)
0019      IF(IERR.LT.0)GO TO 999
0020  30     WRITE(1,35)
0021  35     FORMAT("ENTER IMAGE NO.")
0022      READ(1,*)INUM
0023      IF(INUM.LT.0)GO TO 999
0024      DO 100 LINE=1,512
0025      ICMND= ((INUM-1)*2048+(LINE-1))
0026      CALL EXEC(1,130B,IBUF,256,ICMND)
0027  100    CALL WRITE(IDCB,IERR,IBUF)
0028      GO TO 30
0029      CALL CLOSE(IDCB,IERR)
0030  999    END
```

&JWIMG T=00004 IS ON CR00017 USING 00002 BLKS R=0000

```
0001 FTN7X.L
0002 C
0003 C
0004 C *****
0005 C *
0006 C * THIS PROGRAM WRITES IMAGE ONE LINE AT A *
0007 C * TIME ; USES %WRIMG AND %COMIM *
0008 C *
0009 C *****
0010 C
0011 C
0012 PROGRAM JWIMG
0013 DIMENSION IBUF(512)
0014 2 WRITE(1,5)
0015 5 FORMAT("ENTER IMAGE LEVEL")
0016 READ(1,*)K
0017 IF(K.LT.0)GO TO 999
0018 DO 40 I=1,256
0019 J=256*K
0020 K=IOR(J,K)
0021 40 IBUF(I)=K
0022 LU=30
0023 IMNUM=1
0024 LEN=256
0025 DO 100 LINE=0,511
0026 100 CALL WRIMG(LU,IMNUM,LINE,IBUF,LEN,IERR)
0027 WRITE(1,200)IERR
0028 200 FORMAT("IERR=",I4)
0029 GO TO 2
0030 999 END
```

&JASTR T=00004 IS ON CR00017 USING 00002 BLKS R=0000

```

0001  FTN7X.L
0002  C
0003  C
0004  C      ****
0005  C      *
0006  C      * THIS PROGRAM ADDS OR SUBTRACTS THE TARGET *
0007  C      *
0008  C      * TO/FROM THE IMAGE ; USES %ASTAR, %CMDBL *
0009  C      *
0010  C      * AND %COMIM *
0011  C      *
0012  C      ****
0013  C
0014      PROGRAM JASTR
0015      LU=47
0016  5      WRITE(1,10)
0017  10     FORMAT("ENTER 0=SUB. TARGET, 1=ADD TARGET")
0018      READ(1,*) IFLAG
0019      IF(IFLAG.LT.0)GO TO 999
0020      CALL ASTAR(LU,IFLAG,IERR)
0021      WRITE(1,20) IERR
0022  20     FORMAT(" IERR=",I4)
0023      GO TO 5
0024  999    STOP
0025      END

```

RWTR2 T=00004 IS ON CR00017 USING 00003 BLKS R=0000

```

0001 FTN7X,L
0002 C
0003 C
0004 C *****
0005 C *
0006 C * THIS PROGRAM READS OR WRITES THE TARGET *
0007 C *
0008 C * COORDINATES (FCT=400) ; USES DVR41 *
0009 C *
0010 C *****
0011 C
0012 PROGRAM RWTR2
0013 DIMENSION IBUF(2)
0014 5 WRITE(1,10)
0015 10 FORMAT("ENTER 1= READ TARGET, 2= WRITE TARGET, 0=EXIT")
0016 READ(1,*)IC
0017 IF(IC.EQ.0)GO TO 999
0018 IF(IC.GT.1)GO TO 150
0019 CALL EXEC(1,536B,IBUF,2,0)
0020 WRITE(1,100)IBUF(1),IBUF(2)
0021 100 FORMAT("X=",15,3X,"Y=",15)
0022 GO TO 5
0023 150 WRITE(1,200)
0024 200 FORMAT("ENTER X,Y")
0025 READ(1,*)IX,IY
0026 ICMND=IX
0027 CALL EXEC(2,536B,IDUM,0,ICMND)
0028 ICMND=IY+40000B
0029 CALL EXEC(2,536B,IDUM,0,ICMND)
0030 GO TO 5
0031 999 END

```

&RW TAR T=00004 IS ON CR00017 USING 00003 BLKS R=0000

```

0001  FTN7X,L
0002  C
0003  C
0004  C      ****
0005  C      *
0006  C      *  THIS PROGRAM READ OR WRITES THE TARGET  *
0007  C      *  COORDINATES (FCT=500)  ;  USES DVR41      *
0008  C      *
0009  C      ****
0010  C
0011      PROGRAM RW TAR
0012      DIMENSION IBUF(2)
0013  5      WRITE(1,10)
0014  10     FORMAT("ENTER 1= READ TARGET,      2= WRITE TARGET,  0=EXIT")
0015      READ(1,*) IC
0016      IF(IC.EQ.0)GO TO 999
0017      IF(IC.GT.1)GO TO 150
0018      CALL EXEC(1,436B,IBUF,2,0)
0019      WRITE(1,100)IBUF(1),IBUF(2)
0020  100    FORMAT("X=",15,3X,"Y=",15)
0021      GO TO 5
0022  150    WRITE(1,200)
0023  200    FORMAT("ENTER X,Y")
0024      READ(1,*)IX,IY
0025      ICMND=IX
0026      CALL EXEC(2,436B,IDUM,0,ICMND)
0027      ICMND=IY+40000B
0028      CALL EXEC(2,436B,IDUM,0,ICMND)
0029      GO TO 5
0030  999    END

```

&JRTAR T=00004 IS ON CR00017 USING 00001 BLKS R=0000

```
0001  FTN7X.L
0002  C
0003  C
0004  C      ****
0005  C      *
0006  C      *    THIS PROGRAM READS TARGET LOCATION ;
0007  C      *
0008  C      *    USES %RDTAR, %COMIM
0009  C      *
0010  C      ****
0011  C
0012      PROGRAM JRTAR
0013      WRITE(1,4)
0014  4      FORMAT("ENTER LU NO.")
0015      READ(1,*)LU
0016      CALL RDTAR(LU,IX,IY,IERR)
0017      WRITE(1,200) IERR
0018  200     FORMAT("IERR=",I4)
0019      WRITE(1,220) IX,IY
0020  220     FORMAT(2X,"X=",I4,2X,"Y=",I4)
0021      STOP
0022      END
```

&JW TAR T=00004 IS ON CR00017 USING 00002 BLKS R=0000

```
0001  FTN7X.L
0002  C
0003  C
0004  C      ****
0005  C      *
0006  C      *  THIS PROGRAM ALLOWS THE OPERATOR TO SET THE  *
0007  C      *  TARGET LOCATION ; USES %WRTAR AND %COMIM      *
0008  C      *
0009  C      ****
0010  C
0011      PROGRAM JW TAR
0012      LU=47
0013  5  WRITE(1,10)
0014  10  FORMAT("ENTER IX,IY      , -1=EXIT")
0015      READ(1,*)IX,IY
0016      IF(IX.LT.0)GO TO 999
0017      CALL WRTAR(LU,IX,IY,IERR)
0018      WRITE(1,20)IERR
0019  20  FORMAT("IERR=",I4)
0020      GO TO 5
0021  999  STOP
0022      END
```

&JWGRF T=00004 IS ON CR00017 USING 00003 BLKS R=0000

```

0001  FTN7X,L
0002  C
0003  C
0004  C      ****
0005  C      *
0006  C      *  THIS PROGRAM WRITES GRAPH ONE LINE ; USES  *
0007  C      *  %WRGRF AND %COMIM                               *
0008  C      *
0009  C      ****
0010  C
0011      PROGRAM JWGRF
0012      DIMENSION IBUF(512)
0013  2      WRITE(1,5)
0014  5      FORMAT("ENTER GR. NO.,LINE NO.,LEN      -1=EXIT")
0015      READ(1,*)IGNUM,LINE,LEN
0016      IF(IGNUM.LT.0)GO TO 999
0017      WRITE(1,10)
0018  10     FORMAT("ENTER 0,1 FOR PIXEL LEVEL")
0019      READ(1,*)L
0020      IF(L.EQ.0)GO TO 50
0021      DO 30 I=1,LEN
0022  30     IBUF(I)=177777B
0023      GO TO 100
0024  50     DO 60 I=1,LEN
0025  60     IBUF(I)=0
0026  100    LU=24
0027      CALL WRGRF(LU,IGNUM,LINE,IBUF,LEN,IERR)
0028      WRITE(1,200)IERR
0029  200    FORMAT("IERR=",14)
0030      GO TO 2
0031  999    END

```

&GRFRW T=00004 IS ON CR00017 USING 00005 BLKS R=0000

```
0001 FTN7X.L
0002 C
0003 C
0004 C      ****
0005 C      *
0006 C      * THIS PROGRAM READS OR WRITES A GRAPH *
0007 C      * ONE LINE AT A TIME ; USES DVR41      *
0008 C      *
0009 C      ****
0010 C
0011      PROGRAM GRFRW
0012      DIMENSION IBUF(512)
0013 5      WRITE(1,10)
0014 10     FORMAT("ENTER 1= READ GRAPHIC, 2=WRITE GRAPHIC, -1=EXIT")
0015      READ(1,*)IRW
0016      IF(IRW.LT.0)GO TO 999
0017      WRITE(1,20)
0018 20     FORMAT("ENTER LINE NO.")
0019      READ(1,*)LINE
0020      WRITE(1,30)
0021 30     FORMAT("ENTER NO. OF WORDS")
0022      READ(1,*)LEN
0023      WRITE(1,40)
0024 40     FORMAT("ENTER GRAPHIC NO.")
0025      READ(1,*)INUM
0026      IF(IRW.EQ.1)GO TO 50
0027      WRITE(1,45)
0028 45     FORMAT("ENTER PIXEL VALUE 0, OR 1")
0029      READ(1,*)IVAL
0030      DO 47 I=1,512
0031 47     IBUF(I)=177777B*IVAL
0032 50     ICMND=(((INUM-1)*2048)+512)+LINE)
0033      CALL EXEC(IRW,130B,IBUF,LEN,ICMND)
0034 55     WRITE(1,60)
0035 60     FORMAT("ENTER IBUF NO. -1=EXIT")
0036      READ(1,*)I
0037      IF(I.LT.0)GO TO 5
0038      WRITE(1,70)IBUF(I)
0039 70     FORMAT(06)
0040      GO TO 55
0041 999     END
```

&WINRW T=00004 IS ON CR00017 USING 00003 BLKS R=0000

```

0001  FTN7X.L
0002  C
0003  C
0004  C          ****
0005  C          *
0006  C          * THIS PROGRAM READS OR WRITES WINDOW *
0007  C          * COORDINATES FOR IMAGE OR GRAPHIC ;   *
0008  C          * USES DVR41                             *
0009  C          *
0010  C          ****
0011  C
0012          PROGRAM WINRW
0013          DIMENSION IBUF(4)
0014  5      WRITE(1,10)
0015  10     FORMAT("ENTER 0= READ WINDOW,      1=WRITE WINDOW,      -1=EXIT")
0016          READ(1,*) IRW
0017          IF(IRW.LT.0)GO TO 999
0018          WRITE(1,30)
0019  30     FORMAT("ENTER 0=IMAGE,      1=GRAPHIC")
0020          READ(1,*) IG
0021          WRITE(1,40)
0022  40     FORMAT("ENTER IMAGE OR GRAPHIC NO.")
0023          READ(1,*) INUM
0024          IF(IRW.EQ.0)GO TO 50
0025          WRITE(1,45)
0026  45     FORMAT("ENTER X1,Y1,X2,Y2")
0027          READ(1,*) IBUF
0028  50     CALL RWWSB(24,IG,IRW,INUM,IBUF,IERR)
0029          WRITE(1,60)IBUF
0030  60     FORMAT(4(3X,15))
0031          WRITE(1,70)IERR
0032  70     FORMAT("IERR=",14)
0033          GO TO 5
0034  999    END
0035          SUBROUTINE RWWSB(LU,IG,IRW,INUM,IBUF,IERR)
0036          IERR=0
0037          IF(INUM.LT.0)IERR=-12
0038          IF(INUM.GT.3.AND.IG.EQ.0)IERR=-12
0039          IF(INUM.GT.4.AND.IG.EQ.1)IERR=-12
0040          IF(IG.LT.0)IERR=-12
0041          IF(IG.GT.1)IERR=-12
0042          IF(IRW.LT.0)IERR=-12
0043          IF(IRW.GT.1)IERR=-12
0044          IF(IERR.LT.0)RETURN
0045          IFUNC=1
0046          ICMND=(IG*512)+((INUM-1)*2048)
0047          ICMND=IOR(ICMND,60000B)
0048          IF(IRW.EQ.0)ICMND=ICMND+100000B
0049          CALL EXEC(IRW,LU,IBUF,4,ICMND)
0050          RETURN
0051          END

```

&JRGRF T=00004 IS ON CR00017 USING 00003 BLKS R=0000

```

0001  FTN7X.L
0002  C
0003  C
0004  C      ****
0005  C      *
0006  C      * THIS PROGRAM WRITES GRAPH ONE LINE AT A *
0007  C      * TIME ; USES %RDGRF AND %COMIM *
0008  C      *
0009  C      ****
0010  C
0011      PROGRAM JRGRF
0012      DIMENSION IBUF(512)
0013  2      WRITE(1,5)
0014  5      FORMAT("ENTER GR. NO.,LINE NO.,LEN      -1=EXIT")
0015      READ(1,*)IGNUM,LINE,LEN
0016      IF(IGNUM.LT.0)GO TO 999
0017  100     LU=24
0018      CALL RDGRF(LU,IGNUM,LINE,IBUF,LEN,IERR)
0019      WRITE(1,200)IERR
0020  200     FORMAT("IERR=",I4)
0021  250     WRITE(1,300)
0022  300     FORMAT("ENTER WORD NO. TO OUTPUT")
0023      READ(1,*)J
0024      IF(J.LT.0)GO TO 2
0025      WRITE(1,310)IBUF(J)
0026  310     FORMAT(06)
0027      GO TO 250
0028  999     END

```

&JWPRM T=00004 IS ON CR00017 USING 00003 BLKS R=0000

```
0001  FTN7X.L
0002  C
0003  C      ****
0004  C      *
0005  C      *  THIS PROGRAM WRITES FCT OR PSUEDO      *
0006  C      *  MEMORY ; USES %WRPRM AND %COMIM        *
0007  C      *
0008  C      ****
0009  C
0010  C
0011      PROGRAM JWPRM
0012      DIMENSION IBUF(256)
0013  4      WRITE(1,5)
0014  5      FORMAT("THIS PROGRAM WRITES A RAMP FCT. INTO PROCESSOR MEM." /
0015      1"ENTER IMAGE NO.      -1=EXIT")
0016      READ(1,*) IMNUM
0017      IF(IMNUM.LT.0)GO TO 999
0018      WRITE(1,6)
0019  6      FORMAT("ENTER 0=PSEUDO-COLOR, 1=FCT. MEM.")
0020      READ(1,*) IPF
0021      DO 40 I=1,256
0022  40      IBUF(I)=I-1
0023      LU=24
0024      LEN=256
0025      CALL WRPRM(LU,IMNUM,IBUF,LEN,IPF,0,IERR)
0026      WRITE(1,200) IERR
0027  200      FORMAT("IERR=",I4)
0028      GO TO 4
0029  999      END
```

&JCLM T=0002- IS ON CR00017 USING 00002 BLKS R=0000

```
0001 FTN7X,L
0002 C
0003 C
0004 C
0005 C *****
0006 C * *
0007 C * THIS PROGRAM CLEARS IMAGE OR GRAPH *
0008 C * MEMORY ; USES %CLMEM, %CMDL, %SWAPB, *
0009 C * %COMIM *
0010 C * *
0011 C *****
0012 C
0013 C
0014 PROGRAM JCLM
0015 LU=47
0016 10 WRITE(1,20)
0017 20 FORMAT("ENTER IG,NUM"/"IG=0 FOR IMAGE"/"IG=1 FOR GRAPHIC"/
0018 C"NUM=IMAGE OR GRAPIC NO.")
0019 READ(1,*) IG,NUM
0020 IF(IG.LT.0)GO TO 999
0021 CALL CLMEM(LU,IG,NUM,IERR)
0022 WRITE(1,200) IERR
0023 200 FORMAT("IERR=",I4)
0024 999 END
```

&CMSTA T=00004 IS ON CR00017 USING 00001 BLKS R=0000

```
0001  FTH7X.L
0002  C
0003  C
0004  C      ****
0005  C      *
0006  C      *  THIS PROGRAM GIVES COMTAL STATUS ;  *
0007  C      *  USES DVR41                          *
0008  C      *
0009  C      ****
0010  C
0011      PROGRAM CMSTA
0012  C
0013  C      READS EQT TABLE WORDS 4&5
0014  C      DISPLAYS OCTAL VALUES
0015  C      WD#5      WD#4
0016  C      WD#5 LAST 2 OCT NO.= BITS 0-4 FROM COMTAL CMD CARD
0017  C
0018      WRITE(1,10)
0019  10  FORMAT('ENTER LU #')
0020      READ(1,*)LU
0021      CALL EXEC(13,LU,IST1,IST2)
0022      WRITE(1,20)IST1,IST2
0023  20  FORMAT(06,5X,06)
0024  999  END
```

REFERENCES

1. Martin, Blair R., Comtal Operating Guide, TR#01.2311-0, IBM Corporation, Endicott, N.Y., 1980.
2. Vision One/20 User's Manual, Comtal Corporation, Altadena, CA.

TABLE 1.-ANNOTATION/GRAPHIC/TARGET COLORS*

<u>Color</u>	<u>Annotation</u> (nn)	<u>Graphic</u> (cname)	<u>Target</u> (cname 1)
BLACK	00	BLA	BLA
RED	01	RED	RED
DARK GREEN	02	DGR	
LIGHT ORANGE	03	LOR	
FOREST GREEN	04	FGR	
ORANGE	05	ORN	
GREEN	06	GRN	GRN
YELLOW	07	YEL	YEL
BLUE	10	BLU	BLU
MAGENTA	11	MAG	MAG
DARK TURQUOISE	12	DTU	
PINK	13	PNK	
TURQUOISE	14	TUR	
LIGHT PINK	15	LPI	
CYAN	16	CYN	CYN
WHITE	17	WHT	WHT

* (nn is an octal number representing annotation colors; cname and cname 1 are three letter abbreviations for graphic and target colors respectively.)

TABLE 2.--DEFAULT FUNCTIONS OF 15-KEY ALPHA-PAD

<u>Key</u>	<u>Function</u>
A	DISPLAY IMAGE 1
B	DISPLAY IMAGE 2
C	DISPLAY IMAGE 3
D	DISPLAY IMAGE 1 + ADD PSEUDOCOLOR MEMORY 1
E	DISPLAY IMAGE 2 + ADD PSEUDOCOLOR MEMORY 2
F	DISPLAY IMAGE 3 + ADD PSEUDOCOLOR MEMORY 3
G	DISPLAY IMAGE 1 + ADD FUNCTION MEMORY 1
H	DISPLAY IMAGE 2 + ADD FUNCTION MEMORY 2
I	DISPLAY IMAGE 3 + ADD FUNCTION MEMORY 3
J	DISPLAY FUNCTION MEMORY 1
K	DISPLAY FUNCTION MEMORY 2
L	DISPLAY FUNCTION MEMORY 3
M	DISPLAY IMAGE 8
N	DISPLAY IMAGE 8 + ADD FUNCTION MEMORY 8
O	DISPLAY PSEUDOCOLOR MEMORY

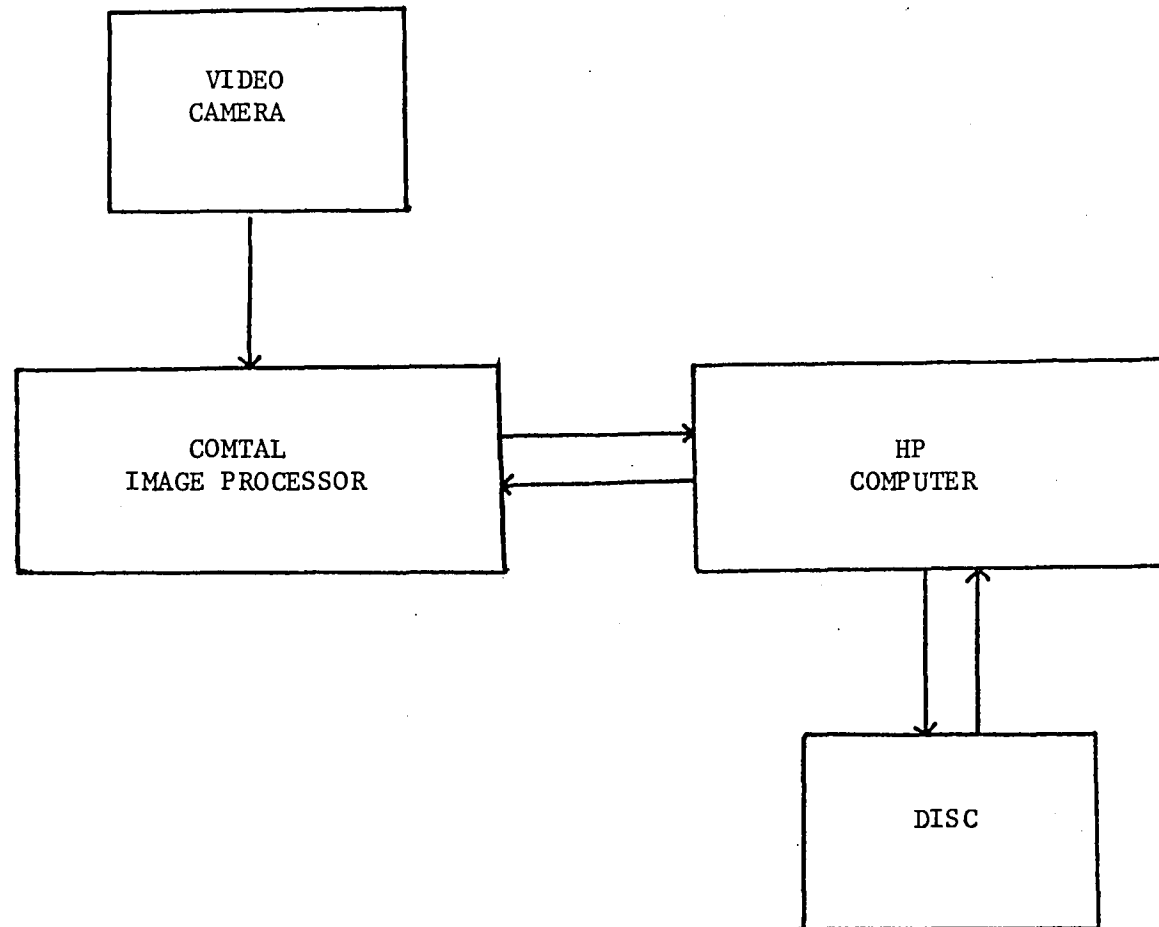


Figure 1.-System Block Diagram

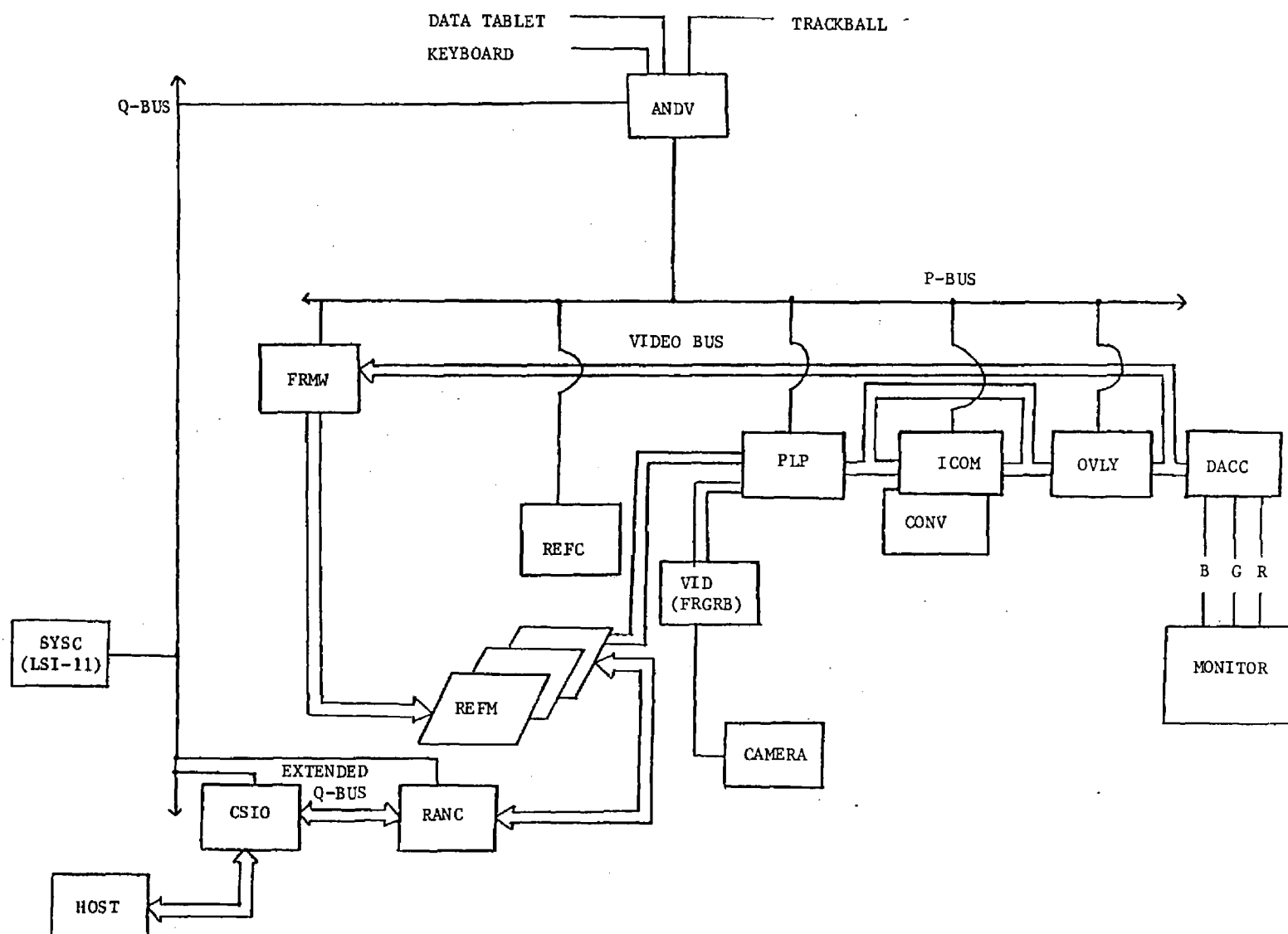


Figure 2.-Vision One/20 Block Diagram

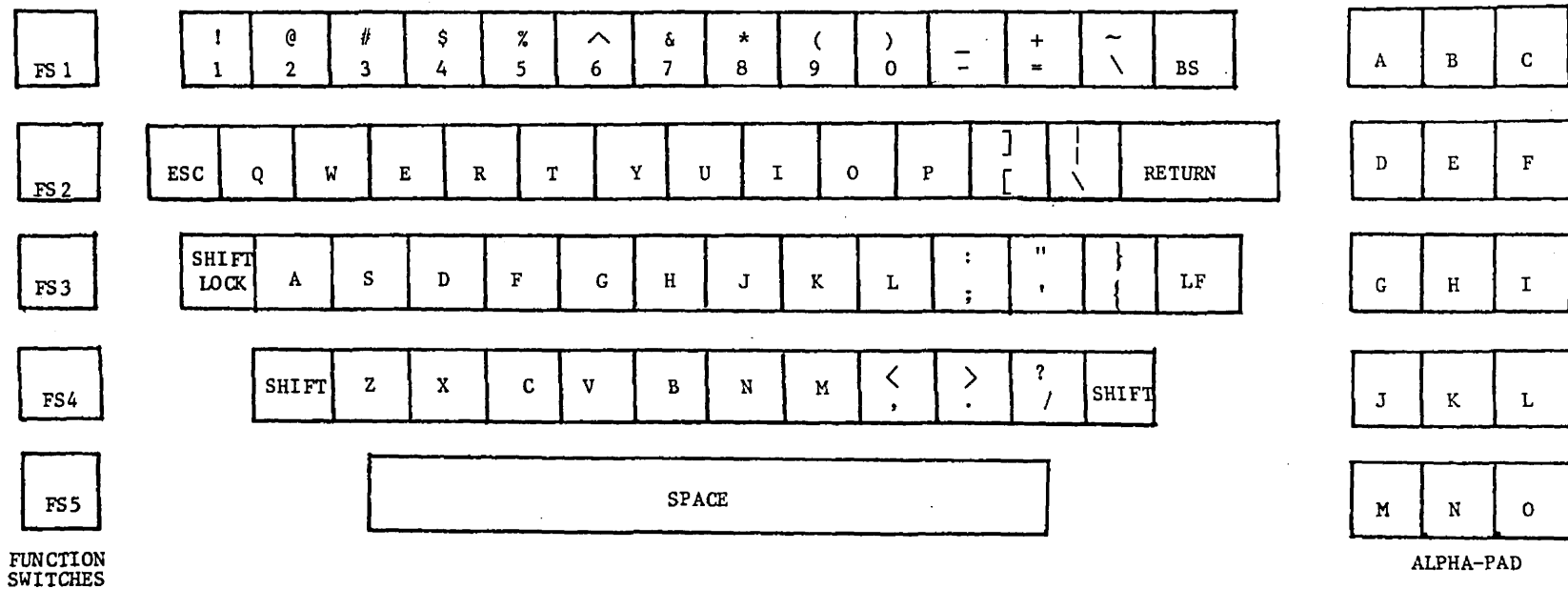
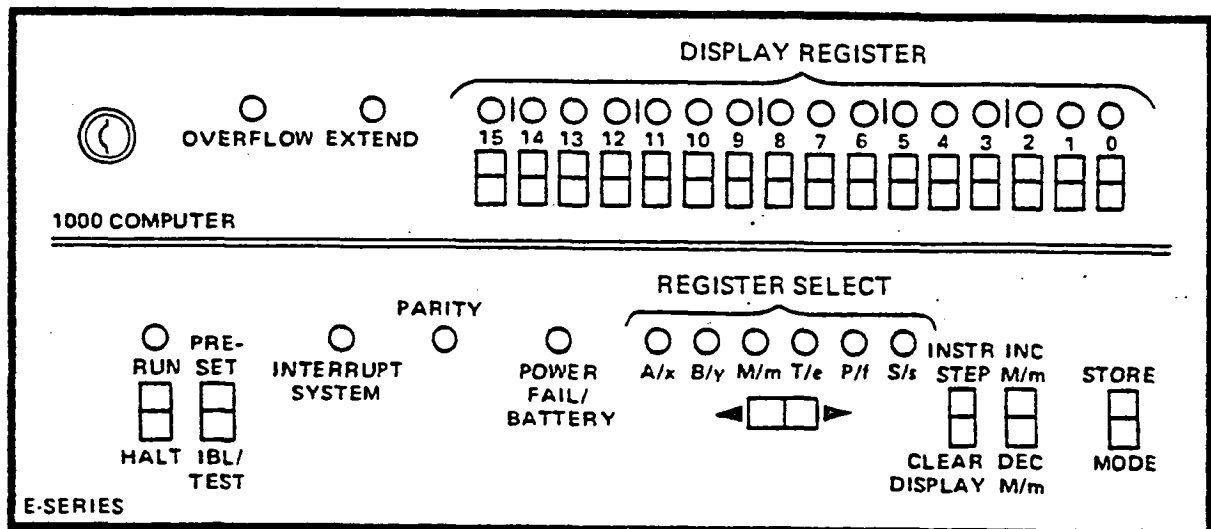


Figure 3.-Comtal Keyboard Configuration

THE FRONT PANEL OF THE COMPUTER



MANUAL BOOTUP is done from the computer's front panel.

Figure 4.-Front Panel of HP Computer

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16. Abstract An image processing system is the combination of an image processor with other control and display devices plus the necessary software needed to produce an interactive capability to analyze and enhance image data. This handbook describes such an image processing system installed at NASA Langley Research Center, Instrument Research Division, Acoustics and Vibration Instrumentation Section (AVIS). Although much of the information contained herein can be found in the other references, it is hoped that this single handbook will give the user better access, in concise form, to pertinent information and usage of the image processing system.					
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